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## ELECTROENCEPHALOGRAPHIC SIGNAL CLASSIFICATION FOR ROBOTIC ARM CONTROL

### Objective

The overall purpose of the Brain Machine Interface Team at UD Vision Lab is to help disabled persons communicate with the world around them. Currently, the robotic arm is used to perform a set of scheduled activities. To enhance functionality, the Emotiv Insight headset will be used to capture raw electroencephalograph (EEG) brainwave data in order to map user motor functions to thought processes.

### System Overview

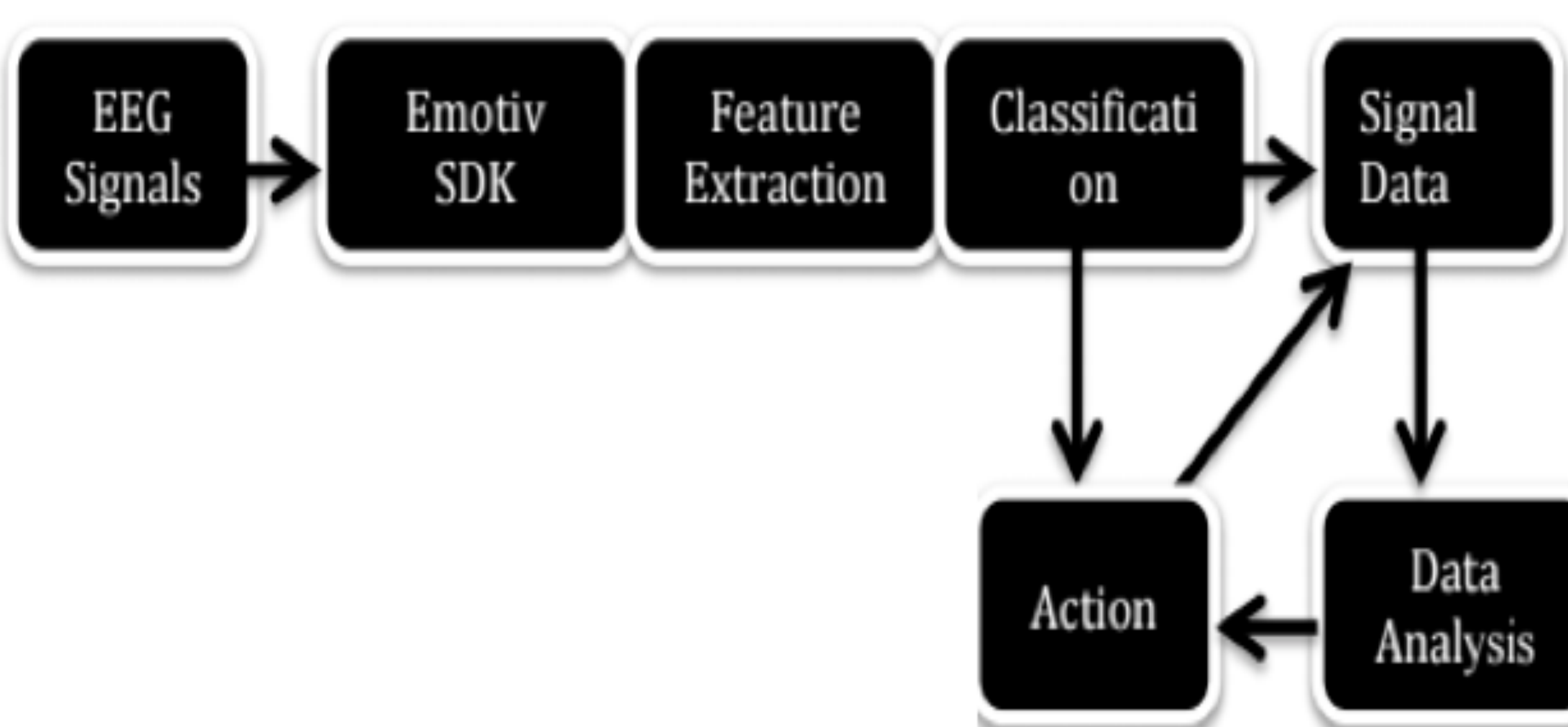
The system utilizes an Emotive Insight EEG headset to interface with a 7 degrees of freedom (DoF) robotic arm, the Robai Cyton Veta.



Emotive Insight

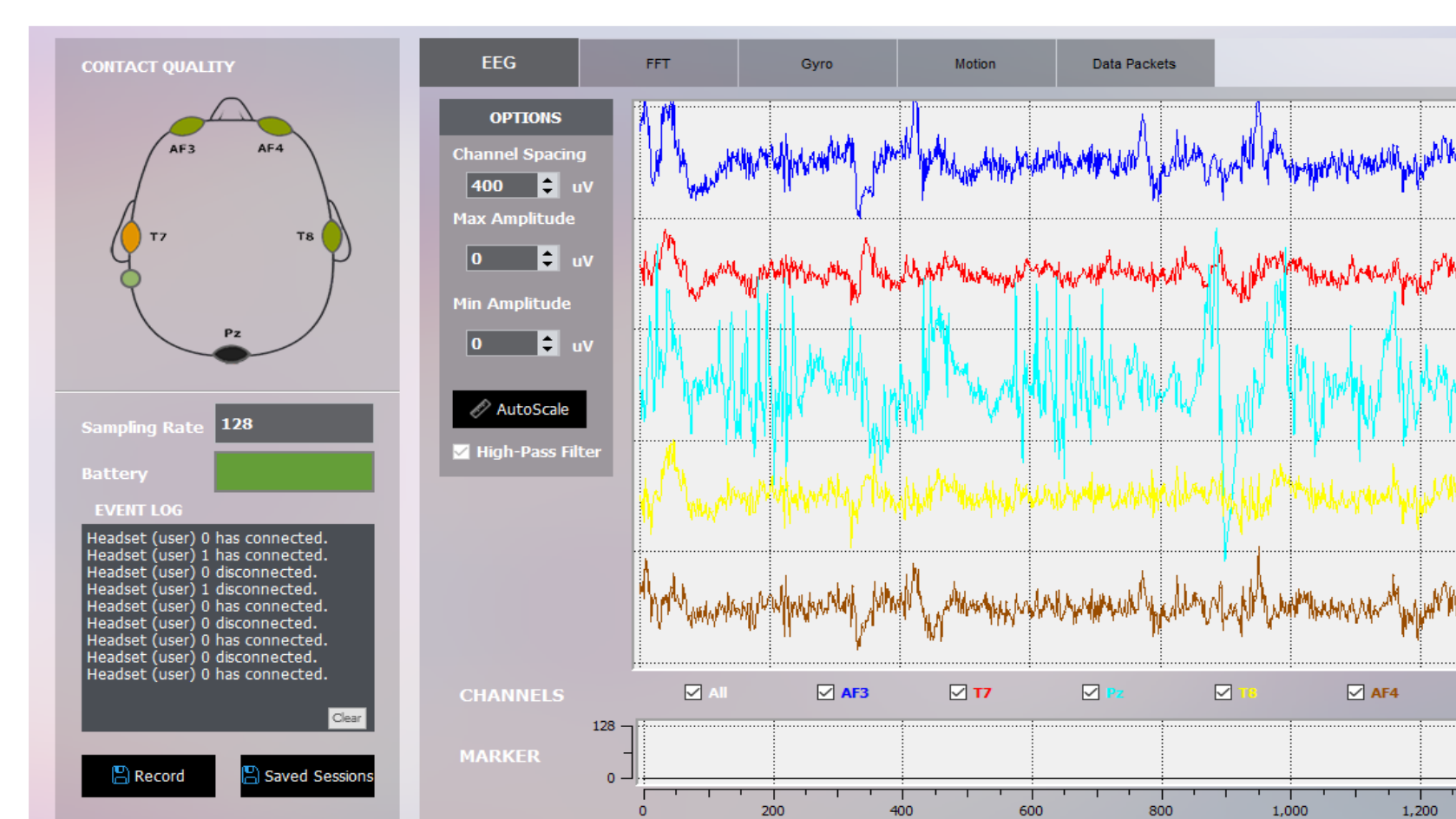


Robai Cyton Veta

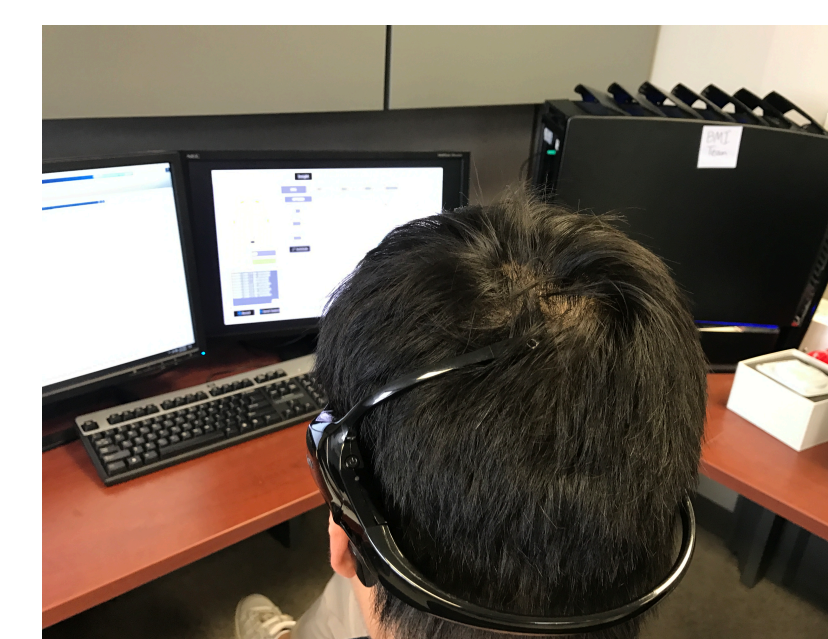


System Flowchart

### Raw Data Acquisition



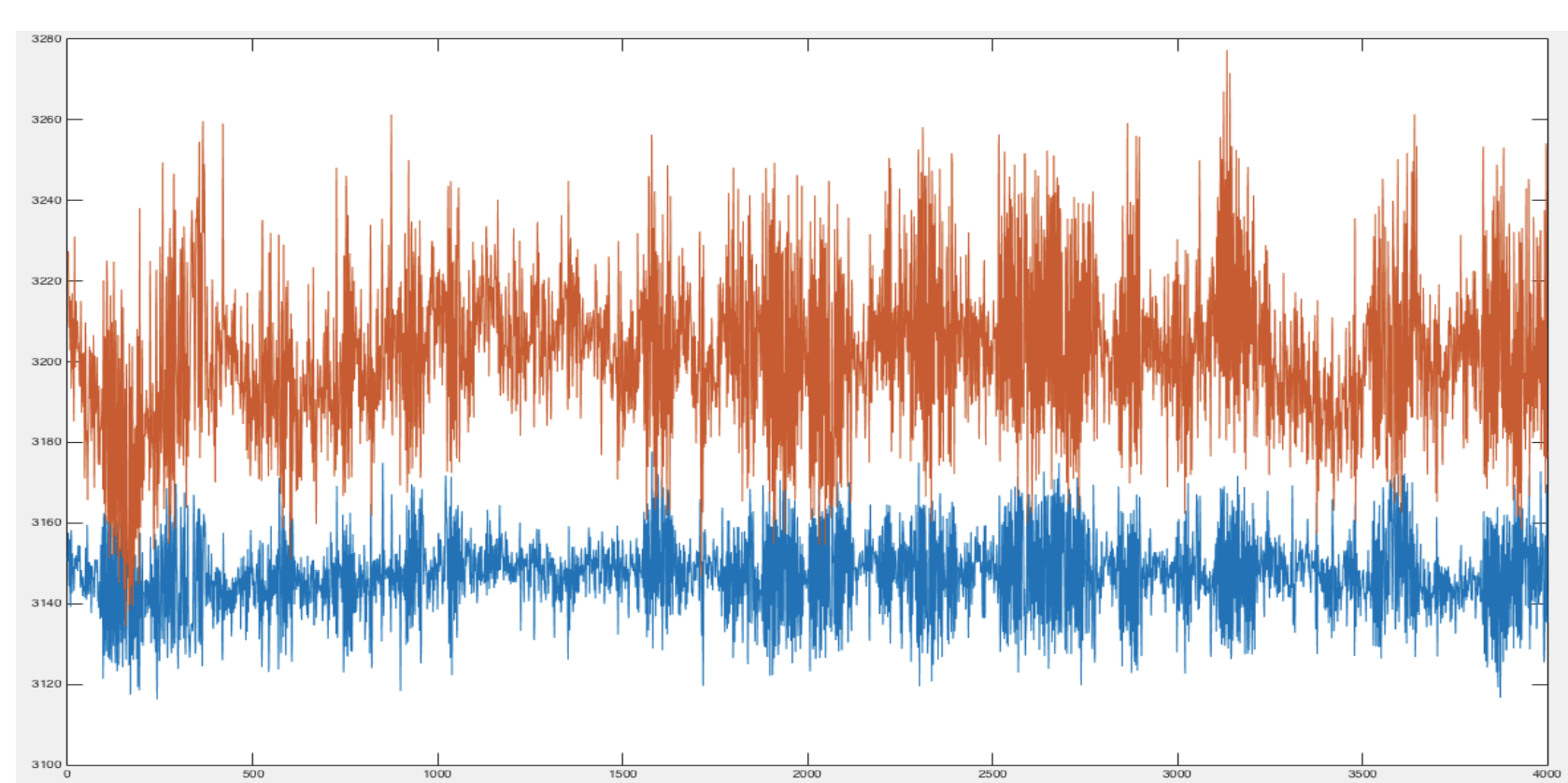
Data Capture from PURE EEG Software Suite



Raw EEG Data Capture

The raw EEG data is captured from the headset by the PURE EEG software.

### Pre-Processing

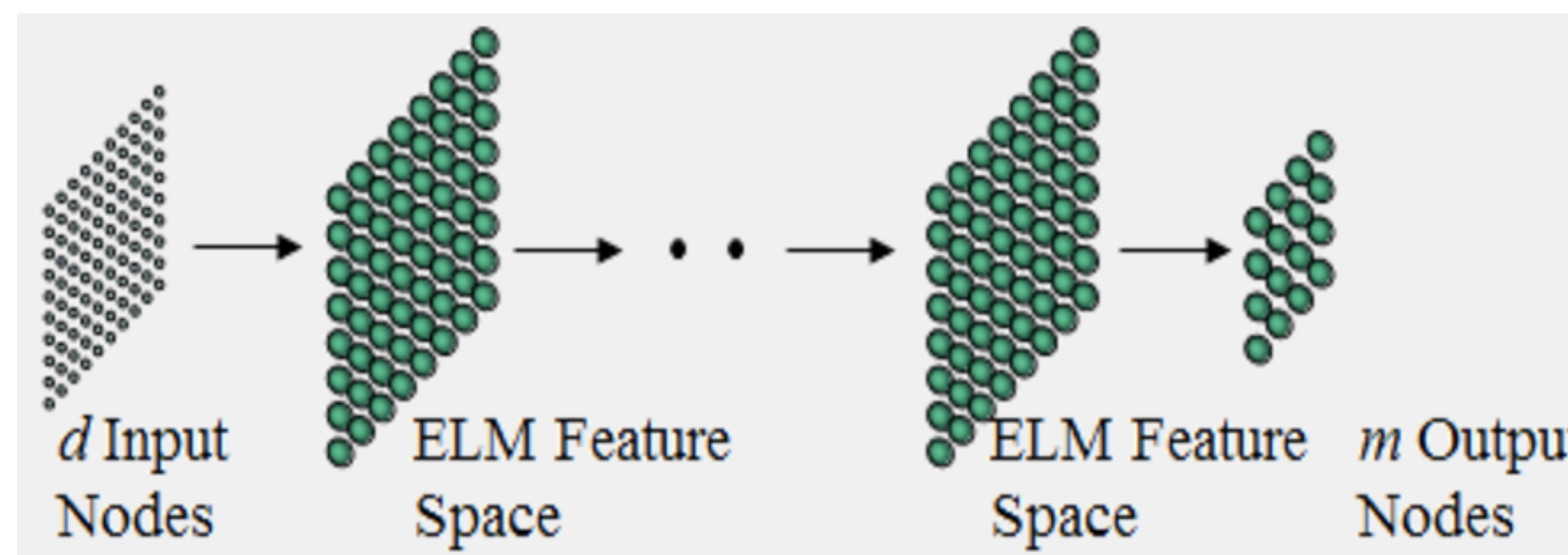


Before and After Removing Noise

Noise and muscle twitches, such as eye blinks and jaw clenches, are removed from the data through filters and a Surface-Laplacian. The orange signal is the data before processing and the blue signal is the data after processing.

### Thoughts Classification

An Extreme Learning Machine (ELM) is utilized in classifying the users thoughts. The ELM promotes real-time learning with high accuracy necessary for processing live data from the user.



ELM Flow Chart

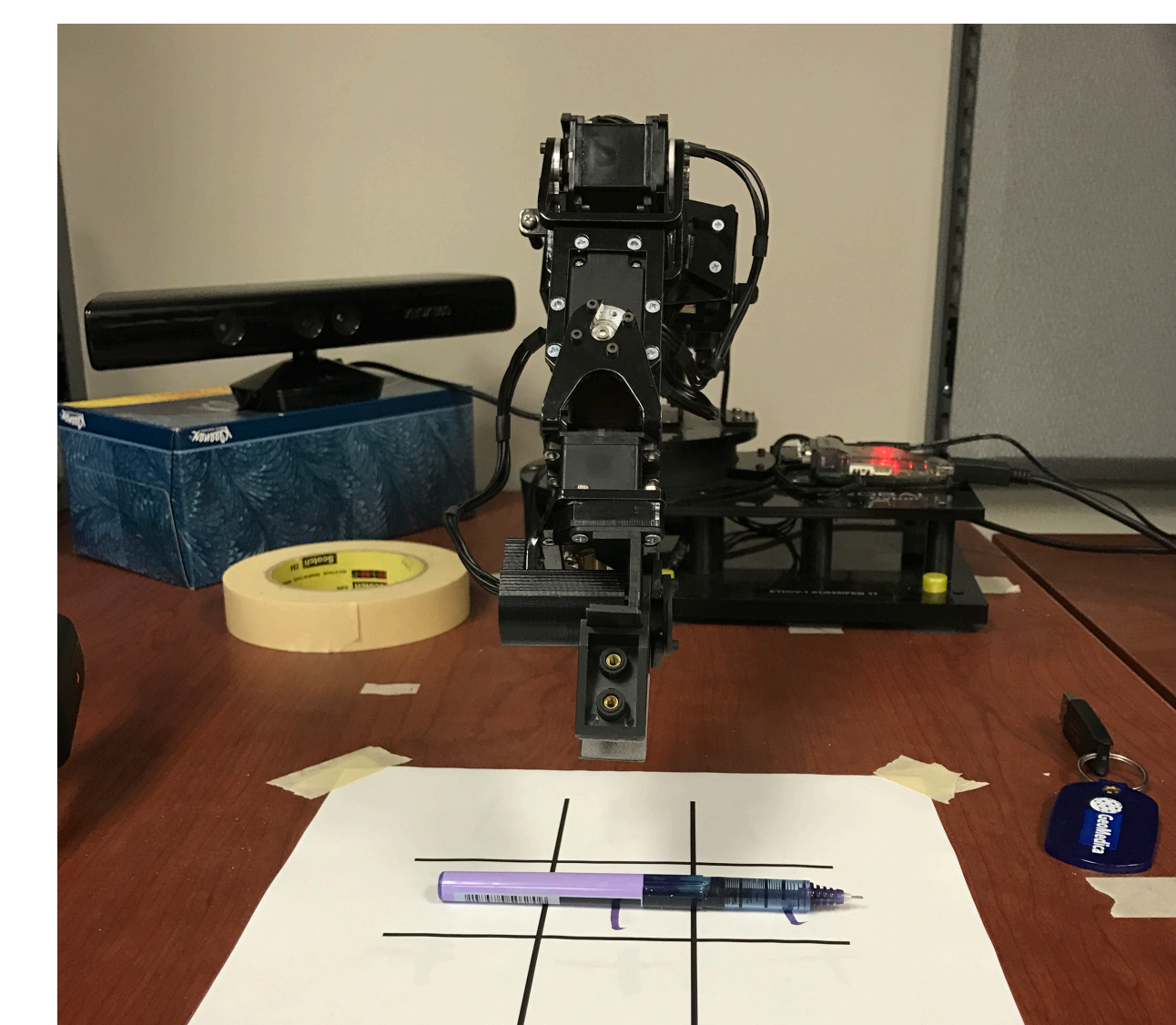
### Future Research

All data processing is done in MATLAB and will need to be converted to C/C++ for live streaming and real time operation of the robotic arm. The Emotiv SDK is utilized to support live streaming. Using the SDK the user will be able to play a game of Tic-Tac-Toe in real time using processed live streamed EEG data.

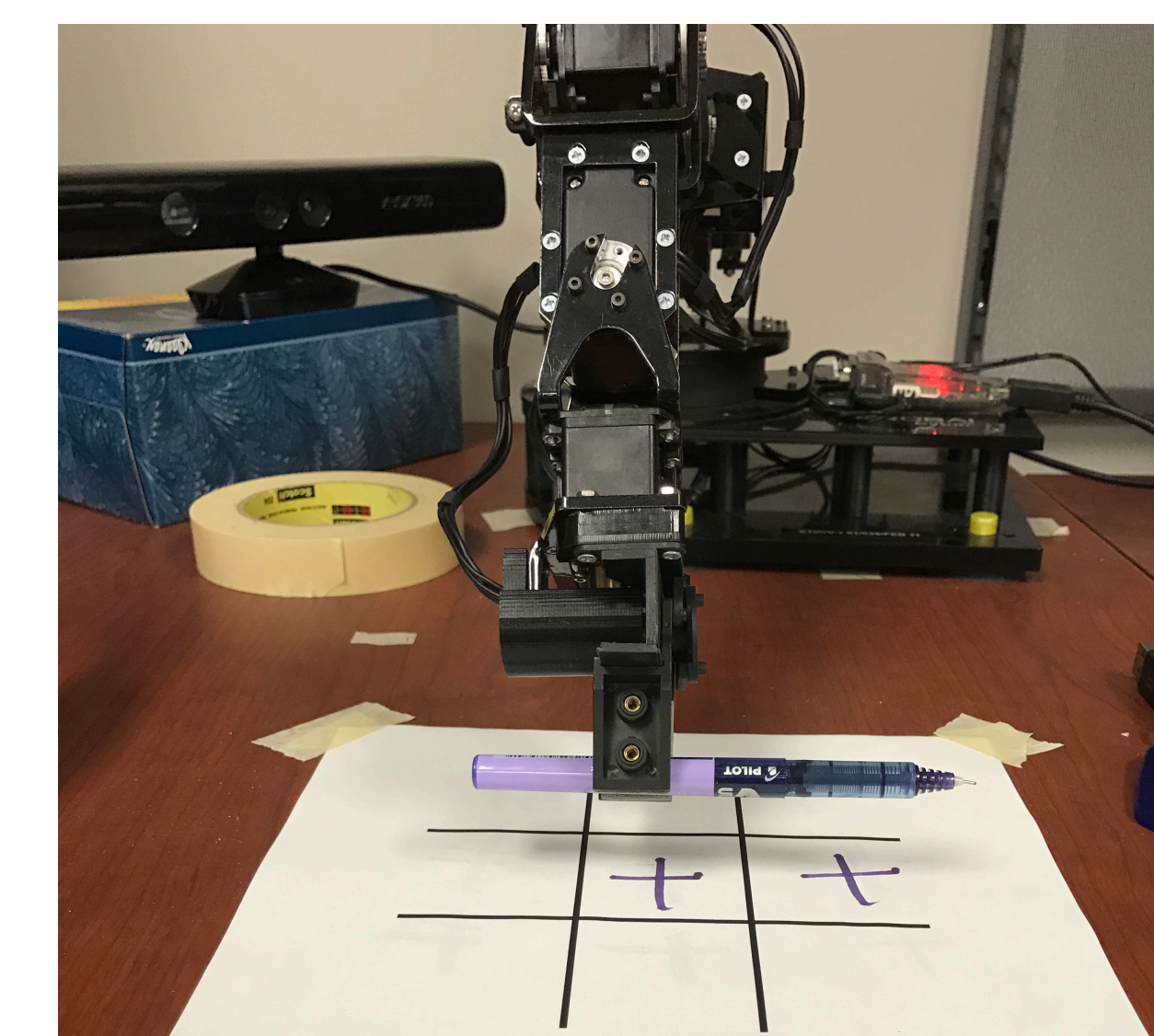
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Example to show how to log the EmoState from EmoEngine/EmoComposer.
Press '1' to start and connect to the EmoEngine
Press '2' to connect to the EmoComposer
>> 1
Start receiving EmoState! Press any key to stop logging...
0: New EmoState from user 0
0: New EmoState from user 0
0:03125: New EmoState from user 0
0:03125: New EmoState from user 0
0:51: New EmoState from user 0
0:51125: New EmoState from user 0
0:625: New EmoState from user 0
0:6875: New EmoState from user 0
0:75: New EmoState from user 0
0:875: New EmoState from user 0
1: New EmoState from user 0
1:125: New EmoState from user 0
1:25781: New EmoState from user 0
1:38281: New EmoState from user 0
1:50781: New EmoState from user 0
1:63281: New EmoState from user 0
1:75781: New EmoState from user 0
1:88281: New EmoState from user 0
2:00781: New EmoState from user 0
2:07031: New EmoState from user 0
2:13281: New EmoState from user 0
2:22650: New EmoState from user 0
2:25781: New EmoState from user 0
2:38281: New EmoState from user 0
2:50781: New EmoState from user 0
2:59150: New EmoState from user 0
2:72781: New EmoState from user 0
2:88281: New EmoState from user 0
3:00781: New EmoState from user 0
3:13281: New EmoState from user 0
3:25781: New EmoState from user 0
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3:51563: New EmoState from user 0
3:64063: New EmoState from user 0
3:76563: New EmoState from user 0
  
```

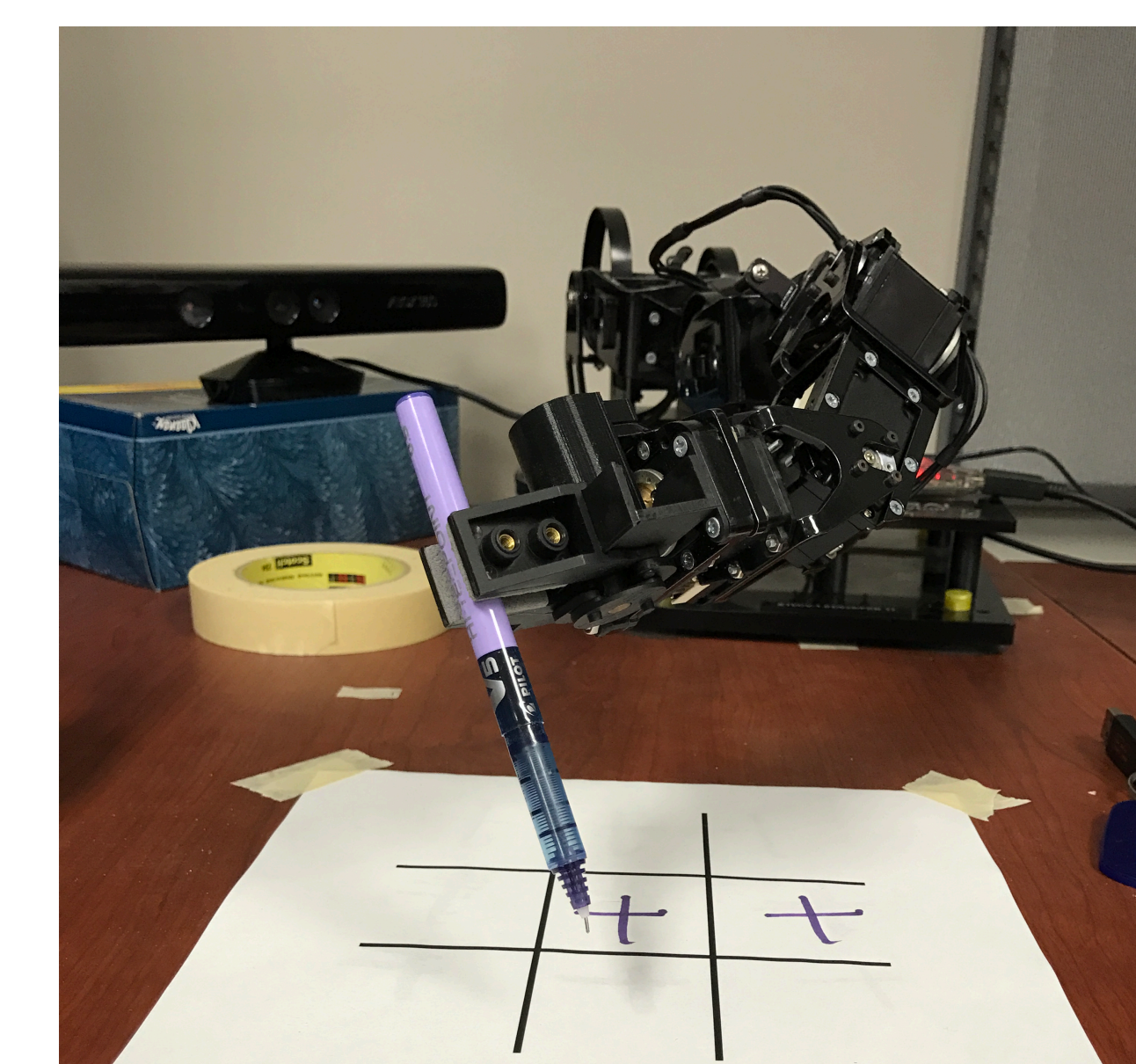
Emotiv Community SDK



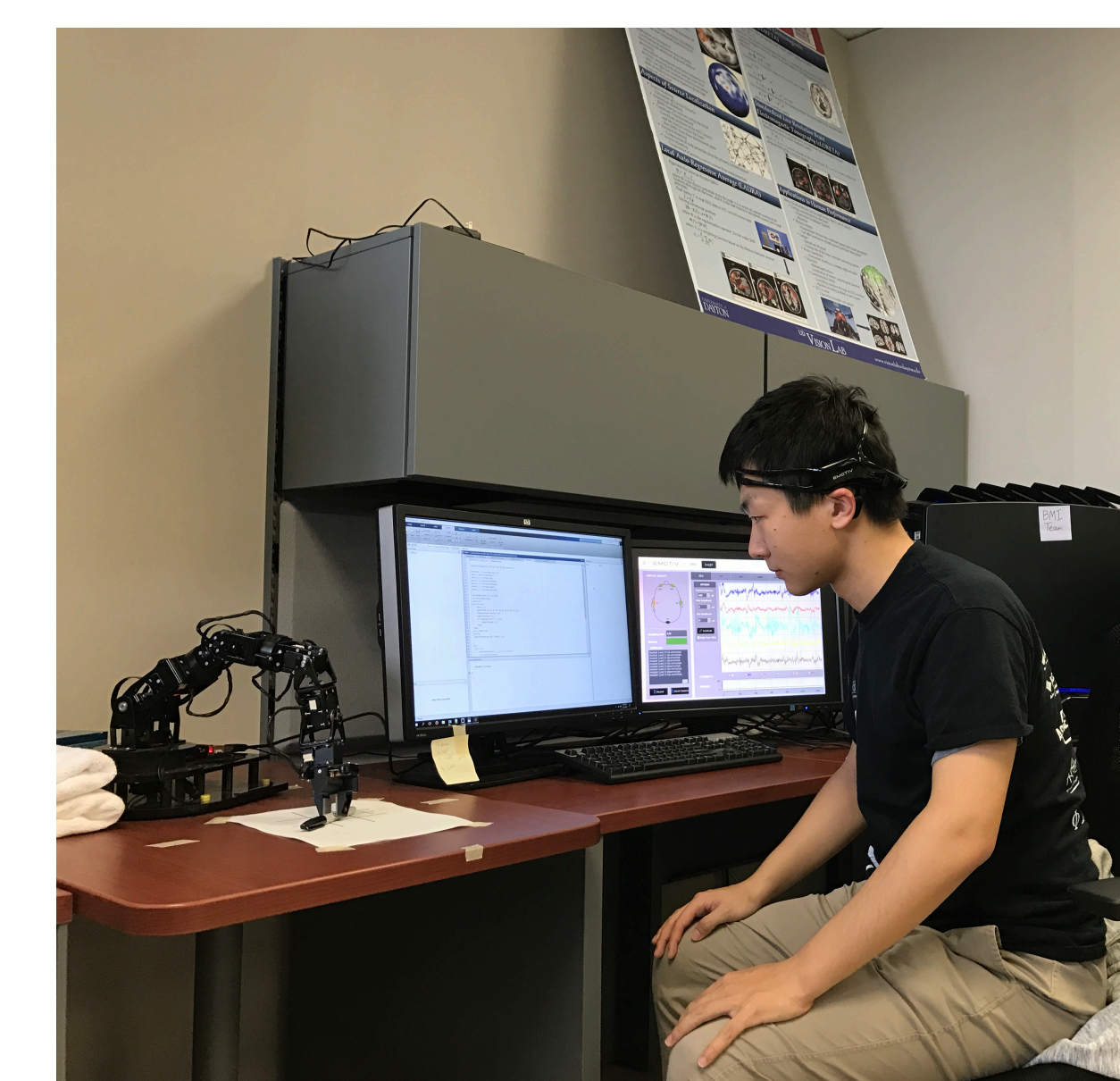
Tic Tac Toe Simulation 1



Tic Tac Toe Simulation 2



Tic Tac Toe Simulation 3



Tic Tac Toe Simulation